Space Weather Technical Forecast

Issued on Tuesday, 19 December 2023 at 01:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Chance of further G1 intervals day 1 (19 Dec). Chance of isolated M-class flares throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity, as measured by GOES16 is Low with occasional mid C-class flares and a peak of C6.5 at 18/1422 UTC from AR3528. AR3514, responsible for the X2.8 flare on 14 Dec has now rotated over the western limb.

Of the ten sunspot regions on the visible disc, two recently emerged regions AR3528 in the northeast and AR3529 in the southeast are the most complex and provide the bulk of the significant flare risk at present. Both have seen an increase in the number of spots and areal extent during the period. A small delta spot may be in the formative stages of development in the case of AR3528. The remaining regions are unipolar or simple bipolar groups, appearing largely stable at this time.

A coronal dimming was evidenced from AR3519 following a low-level C-class flare at 18/0930 UTC, however, no CME was detected in coronagraph imagery. Therefore there are no new Earth-directed CMEs.

Solar Wind / Geomagnetic Activity: The solar wind environment was indicative of one or more CME influences, followed by the onset of a HSS from CH82/+ late in the UTC day on 18 Dec. Solar wind as measured by DSCOVR and ACE at L1, was slightly elevated at first, increasing briefly to elevated levels between 18/1500-1600 UTC, then rising more persistently to elevated to strong levels, with a peak of 632km/s at 18/2330 UTC. Density varied, but was largely at above average levels, peaking at 28ppcc at 18/0959 UTC. The IMF was mostly moderate with a peak of 13nT at 18/1036 UTC and with a north-south component of +12/-12nT. The magnetic field showed significant variability and the phi angle was generally positive (away from the Sun). Resultant geomagnetic activity was largely Quiet to Unsettled (Kp2-3), but with a single G2 (Kp6) interval from 18/0600-0900 UTC and a G1 (Kp5) interval from 18/2100-2400 UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux declined to background levels, having been raised in response to the recent larger flares from AR3514. It was below the S1/Minor Radiation Storm threshold throughout the last 24 hours. GOES16 high energy (greater than 2MeV) electron flux was mostly at Normal Background levels. The 24-hour fluence was well below the Active threshold (1e8 integrated pfu) on a mostly stable trend. The observation at 18/0001UTC was 1.24e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low with a chance of becoming Moderate with isolated M-class flares. The greatest risk of significant flares is currently from AR3528 and AR3529, although may be supplemented by the potential for several new or returning regions to rotate over the eastern horizon during the period.

Solar Wind / Geomagnetic Activity: There is one further weak possible CME in the forecast, with arrival mooted for later day 1 (19 Dec) or early day 2 (20 Dec). The other component of the forecast, a persistent coronal hole, has arrived with ongoing strong solar winds that should slowly ease in the coming days to elevated or slightly elevated levels, ahead of a further fast wind enhancement on day 4 (22 Dec) with elevated winds expected at peak.

Geomagnetic activity is expected to be at Active to G1/Minor Storm levels at first on day 1 (19 Dec) soon easing to become Quiet to Unsettled, with isolated Active intervals likely late 19 Dec.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

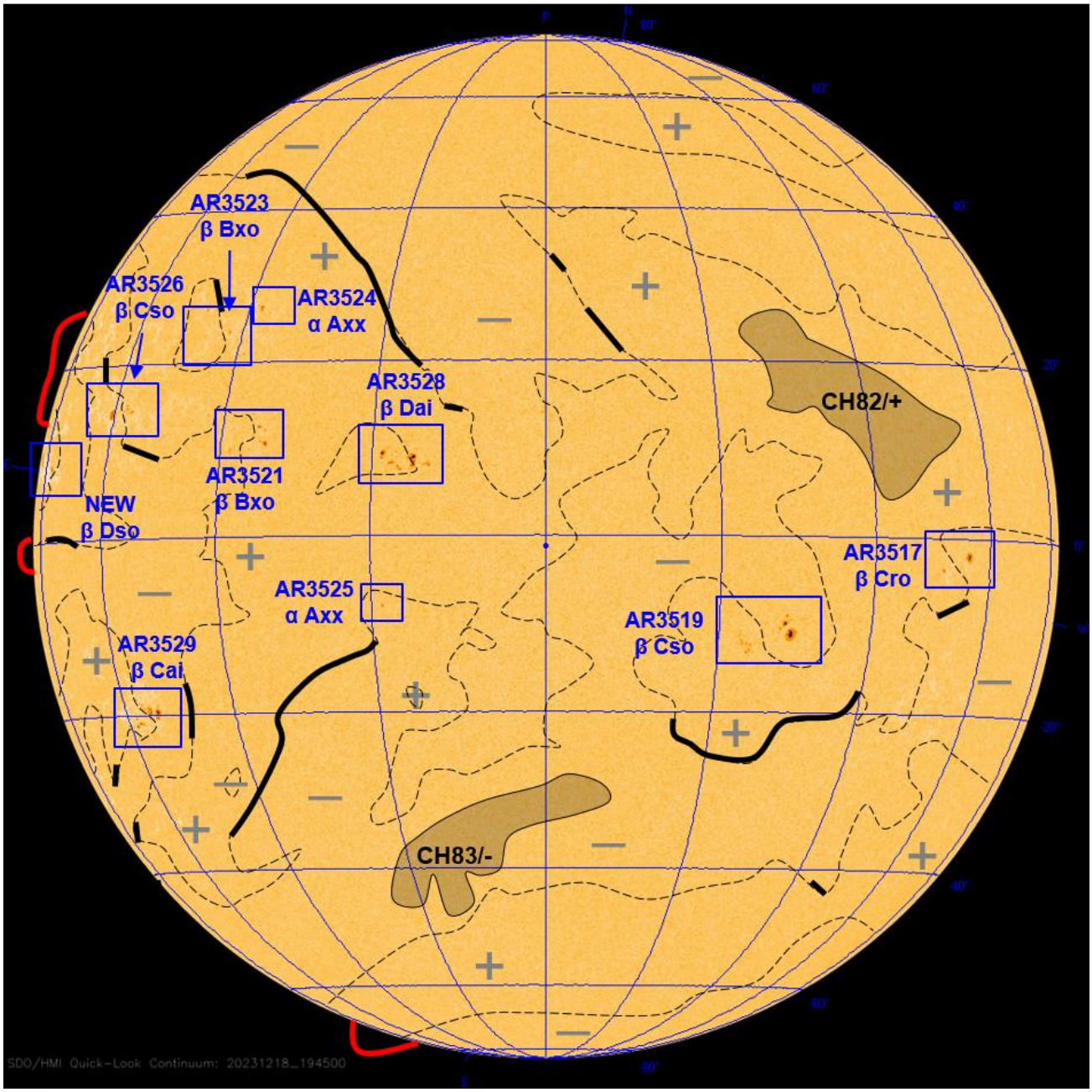
© Crown Copyright 2023. All Rights Reserved.

Activity then Quiet to Unsettled from day 2 to day 3 (20-21 Dec), before increasing day 4 (22 Dec) to Unsettled to Active, with a slight chance of G1/Minor Storm conditions at peak.
Energetic Particles / Solar Radiation: GOES16 high energy proton flux is now at Background levels and expected to remain at similar levels unless any further significant flaring occurs.
High energy electron flux is likely to be stymied at GEO by the recent CME and HSS arrivals. The associated 24-hour electron fluence should therefore mostly remain near current levels, with any more appreciable rise probably delayed until day 3 (21 Dec) after midweek UTC given a second inbound CME due into Wednesday.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 18/1945 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

There is one potentially Earth-directed CME in the forecast, resulting from the 15/2100 UTC south-centre disc filament eruption. This is low confidence for two reasons - firstly the analysis used scant, faint coronagraph imagery and was only tentatively linked to the event in question. Secondly, MOSWOC Enlil is late and too slow with CH82/+ fast wind which has recently reached 600-630km/s. Indicated faster solar winds should allow the CME to progress quicker through interplanetary space and could arrive sooner on day 1 (19 Dec) with a reduced likelihood of effects on day 2 (20 Dec) compared to previous forecasts for this event. Although rather uncertain, given the CME's central position, Earth impacts are considered fairly likely but probably muted for being slow and weak.

Enhanced solar winds from CH82/+ have reached strong levels. Speeds should peak between 600-650km/s on day 1 (19 Dec) before declining in the following days to elevated or slightly elevated levels. The next HSS enhancement is likely from CH83/- on day 4 (22 Dec). This is a recurrent feature that saw peak speeds of 550-600km/s on the previous rotation, although was coincident with a period of enhanced geomagnetic activity associated with a notable CME arrival, so peak speeds carry moderate confidence.
Geomagnetic activity is expected to be at Active to G1/Minor Storm levels at first on day 1 (19 Dec) soon easing to become Quiet to Unsettled, with isolated Active intervals likely late 19 Dec. Activity then Quiet to Unsettled from day 2 to day 3 (20-21 Dec), before increasing day 4 (22 Dec) to Unsettled to Active, with a slight chance of G1/Minor Storm conditions at peak.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	50	10	1	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1947	Partial	Filament eruption	S Centre	341 km/s	Late 19 or early 20 Dec	Low confidence

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

Although current activity is Low, there remains a daily chance of isolated M-class flares.
Ten sunspot regions feature on the visible disc. Most regions appear relatively stable as either unipolar or simple bipolar groups, however there are a couple of developmental regions that require considering. These are AR3528 and AR3529, both of which have seen an increase in the number of spots and growth in penumbral extent. The former may also be in the formative stages of a delta spot developing towards the leading portion of the group. The new, as yet unnumbered region close to the northeast limb is still significantly foreshortened in available imagery, however, it does appear to be a bipolar group and has been reclassified as such. It may reveal further complexity as it rotates into clearer view.

Several new or returning sunspot regions are expected to appear over the eastern solar horizon in the period, however far-side soundings and limb EUV flux are not readily backed up by CME and dimming evidence to suggest anything comparable making up for the loss of Ex-AR3514.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	35	30	30	25
Very Active	R3 to R5 X Class	No	3	3	3	2

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is now at normal Background levels and expected to remain at similar levels unless any further significant flaring occurs.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):
High energy electron flux is currently mostly at Normal Background levels and is expected to remain so in the immediate term. The fast wind from CH82/+ and a potential further CME 19-20 Dec are then likely to suppress levels at GEO once again for a time, but with the eventual easing probably allowing for the peak risk of Active fluence for the forecast as a whole - perhaps a slight chance by day 3 (21 Dec).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.